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## 626 POLYMERS FROM RENEWABLE SOURCES

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Table 2. Applications of Starch Derivatives<sup>a</sup>

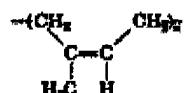
Starch or derivative	Applications	Ref.
glycol starches	urethane foams, surfactants, alkyl resins	43-46
combination with poly(ethylene-co-acrylic acid) and polyethylene carboxymethylstarch	biodegradable materials as switch film	47
starch reinforcement of rubber	water-soluble laundry-detergent bags	48
droplets, powdered rubber in latex	assist in rubber manufacture	49
immobile starch starches	removal of heavy metal contaminants from industrial process water	50
graft starch products <sup>b</sup>	absorption of body fluids; thickening agents; fire control; removal of water in fuel-alcohol mixtures	56,51,52

<sup>a</sup> Ref. 4.<sup>b</sup> Including Super Starch.

## Rubber and Gutta Percha

Natural rubber has been used for a long time. Columbus noticed that the natives of Haiti played with balls prepared from the gum of a local tree (53). Rubber is present in the *Hevea* tree (*Hevea brasiliensis*) as a natural latex or in submicroscopic dispersion in a saplike material. These latexes appear milk-white. The first commercial rubber was obtained from trees in Brazil (see RUBBER, NATURAL).

Natural rubber consists of poly(*cis*-1,4-isoprene).



The *cis* isomer is usually an amorphous solid with a  $T_g$  of  $-72^\circ\text{C}$ ; it melts at  $27^\circ\text{C}$  if crystallized. The *trans* isomer, known as gutta percha or balata, is a highly crystalline polymer; sources are given in Table 9. The most important sources are the plantations in Malaysia and Indonesia.

**Production.** The commercial growth of natural rubber developed rapidly with the invention of the pneumatic tire. Beginning with World War II, the

Table 3. Sources of Rubber

Common name	Botanical name	Region
<i>Poly(cis-1,4-isoprene)</i>		
natural rubber	<i>Hevea brasiliensis</i>	Brazil, Malaysia, Mexico, Texas
gumule	<i>Parthenium argenteum</i>	USSR
donedion	<i>Turnera</i>	
<i>Poly(trans-1,4-isoprene)</i>		
gutta percha	<i>Peleaum gutta</i>	Malaysia
	<i>Dioscorea gutta</i>	
balata	<i>Balata tree</i>	Brazil